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(54) I.c. engine piston and connecting rod assembly

(57) A cup-shaped liner 32, eg of carbon steel, is fixed inside a hollow piston 31, eg of aluminium. The gudgeon pin 33 is an interference fit in a aperture 35a in a cylindrical carrier 35 which is a sliding fit within the liner 32. A ring 36 limits movement of the carrier 35 towards the crankshaft. A set of disc springs 39, eg of titanium, act between the top of the carrier 35 and the crown 31a of the piston 31 to bias the connecting rod 34 away from the piston 31. The spring may alternatively be provided between the ends of the connecting-rod 34. The arrangement is such that the piston can move towards the crank-pin by a distance equal to the clearance height. Ignition occurs before TDC so that the piston is at first forced inwards against the force of the springs 39 which increases the volume above the piston 31, causing a reduction in pressure and temperature in the cylinder. The energy stored in the springs 39 is released after TDC. Efficiency is increased and exhaust emissions reduced.

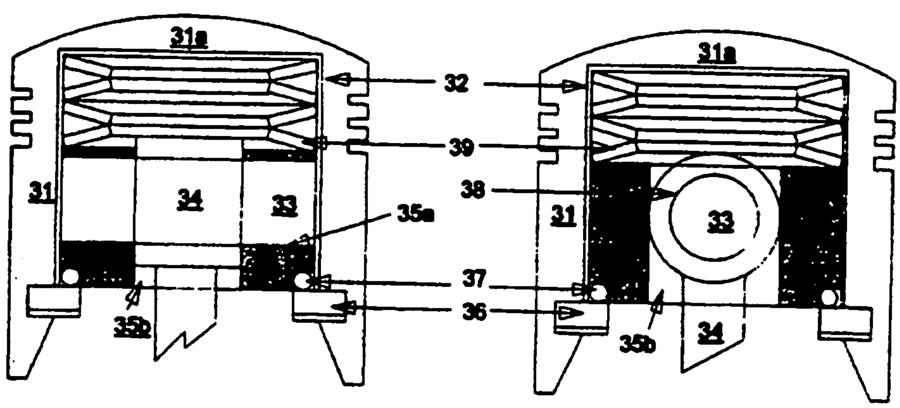

FIG 1 FIG 2

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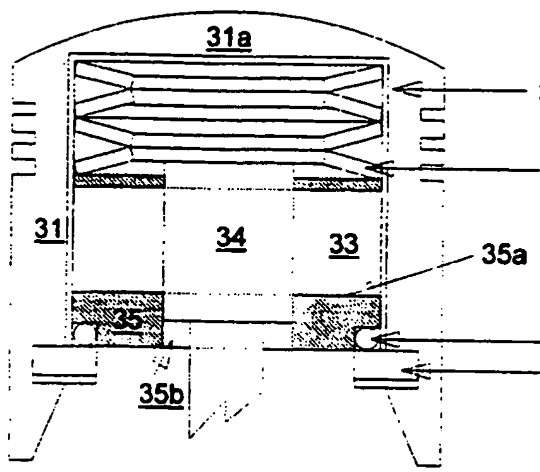

FIG 1

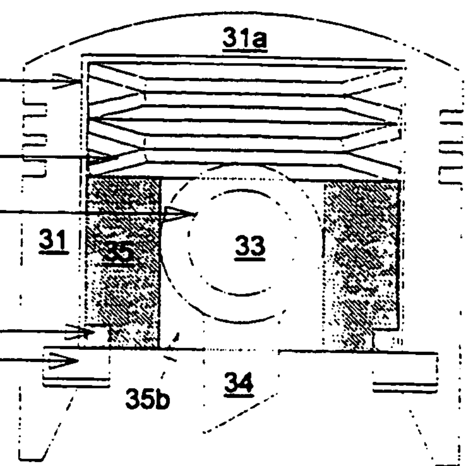

FIG 2

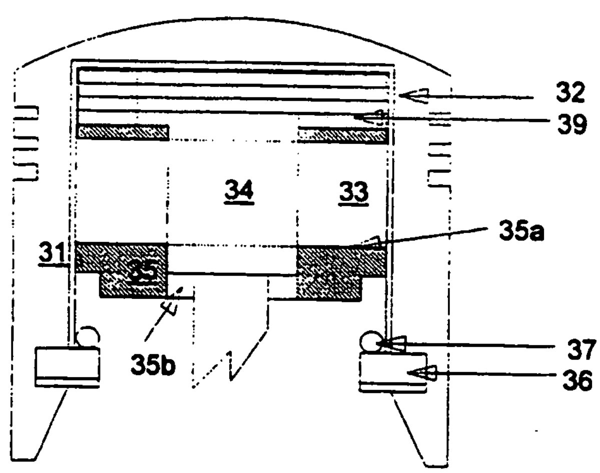

FIG 3

Piston and Connecting Rod Assembly

This invention relates to a piston and connecting rod assembly for an internal combustion engine.

A conventional internal combustion engine employs a crankshaft to convert the reciprocating motion of the piston(s) into output torque to propel a vehicle or act upon any other load. The crankshaft is inefficient in its ability to convert the power available from the fuel combustion into usable output torque. This is because combustion of the fuel/air mixture takes place a number of degrees before the top dead centre (TDC) position of the piston, dependent upon engine speed and load. The ignited fuel/air pressure forces cannot produce output torque when the piston is either before or at TDC as the connecting rod and the crank pin are producing reverse torque before TDC and practically in a straight line at TDC so that there is no force component tangential to the crank circle. This results in most of the available energy being lost as heat. If ignition takes place too early, most of the pressure generated is wasted trying to stop the engine (as this pressure tries to force the piston in the opposite direction to which it is travelling during the compression stroke); and, if left too late, the pressure is reduced due to the increasing volume above the piston as it starts its descent for the power stroke. The optimum maximum pressure point varies from engine to engine, but is around 12^0 after TDC on average.

The present invention provides a piston and connecting rod assembly for an internal combustion engine, the assembly comprising a piston, a connecting rod, and a spring, the connecting rod having a first end operatively associated with the piston for movement therewith, and a second end connectible to a rotary output shaft, wherein the spring acts between the piston and the connecting rod to bias the connecting rod away from the crown of the piston.

Advantageously, the piston is hollow, and the connecting rod is connected to the piston by a gudgeon pin, and the spring acts between the piston crown and the gudgeon pin, the gudgeon pin being movable relative to the piston

in the axial direction thereof.

Preferably, the gudgeon pin is mounted within a carrier which is slidably mounted within the hollow piston for axial movement relative thereto. The movement of the carrier within the piston may be limited by the spring in the direction of movement towards the crown, and by a stop member fixed in the interior of the piston in the direction of movement away from the crown.

In a preferred embodiment, a set of disc springs constitutes the spring. The disc springs may be made of titanium.

The invention also comprises an internal combustion engine comprising a cylinder, a piston and connecting rod assembly as defined above, a rotary output shaft, means for igniting a fuel/air mixture in the cylinder, and means for actuating the ignition means, the actuating means being such that ignition takes place before the piston reaches TDC on the compression stroke, and the arrangement is such that the spring is compressed, by the expanding gases resulting from the combustion following ignition, before the piston reaches TDC.

The invention will now be described in greater detail, by way of example, with reference to the drawings, in which:-

Figure 1	is a schematic, part-sectional side elevation of a piston/connecting rod assembly constructed in accordance with the invention;
Figure 2	is a schematic, part-sectional front elevation of the assembly of Figure 1; and
Figure 3	is a schematic, part-sectional side elevation similar to that of Figure 1, but showing the assembly in a different operating configuration.

Referring to the drawings, Figure 1 shows a hollow piston 31 of an internal combustion engine, the piston being made of aluminium and being reciprocable in a cast iron cylinder (not shown) in a conventional manner. A cup-shaped liner 32 made of carbon steel is fixed within the piston 31 by means of a

bayonet or other suitable connection. In use, the piston 31 turns a crankshaft (not shown) by means of a gudgeon pin 33, a connecting rod 34, and a crank pin (not shown), all of which are made of carbon steel. The gudgeon pin 33 is an interference fit within a cylindrical aperture 35a formed within a cylindrical carrier 35 made of aluminium. The carrier 35 is a sliding fit within the liner 32, a ring 36 made of aluminium and fixed to the internal wall of the piston 31 constituting a stop for limiting movement of the carrier towards the crankshaft within the piston. A Viton O-ring 37 is provided to act as a buffer between the carrier 35 and the ring 36. The arrangement is such that the piston 31 is able to move towards the crank pin by a distance approximately equal to the cylinder clearance volume height (the distance between the mean height of the crown 31a of the piston 31 and the mean height of the top of the combustion chamber).

The connecting rod 34 passes through a generally rectangular aperture 35b formed in the carrier 35, and is connected to the gudgeon pin by a small end bearing 38. The square aperture 35b is at right-angles to the cylindrical aperture 35a. A set of disc springs 39 made of titanium is positioned between the top of the carrier 35 and the crown 31a of the piston 31, so as to bias the connecting rod 34 away from the piston crown.

In use, ignition is timed, by conventional timing means (not shown), to take place at a predetermined time before TDC, so that the expanding gases formed by the ignition combustion force the piston 31 to descend rapidly within the cylinder during the power stroke. Prior to reaching TDC, however, the pressure in the cylinder will build up to a high value, and the piston 31 is forced towards the crank pin, against the force of the disc springs 39, with respect to the carrier 35. This compresses the disc springs 39 (as shown in Figure 3 - which shows the arrangement at the start of the power stroke), and increases the volume above the piston 31, causing a reduction in pressure and temperature in the cylinder. The lowered temperature reduces radiation losses and the heat lost to the cooling water and subsequently the exhaust, with the pressure being shared

equally between the cylinder clearance volume and the disc springs 39. This energy stored in the disc springs 39 is released when the piston 31 has passed TDC, and leads to the production of output torque. This is achieved as the spring pressure is now combined with the cylinder pressure after TDC. A large proportion of this stored energy would otherwise have been lost as heat, owing to the fact that the fuel/air mixture must be ignited before TDC, which is a result of the requirement for the ignited fuel/air to reach maximum pressure by about 12^0 after TDC for optimum performance.

The action of this arrangement means that, when the engine is firing normally, there will be movement of the piston 31 with respect to the connecting rod 34 (and hence to its crank pin) on every power stroke. The ignition timing of the engine is such that ignition occurs between approximately 10^0 and 40^0 before TDC, depending upon the engine's load and speed.

The affect of providing the energy storing springs 39 is to reduce considerably the engine fuel consumption without reducing its power output. Up to 30% improvement can be achieved without a compression ratio adjustment, and up to 60% with compression ratio adjustment.

Not only is the efficiency of the engine improved, but the exhaust emissions are also reduced. Thus, by decreasing the fuel consumption, the quantity of emissions is reduced; by lowering the temperature of combustion (in the non-increased compression ratio case) , the nitrous oxide emissions are greatly reduced; and, by increasing the efficiency of the engine, unburnt hydrocarbon emissions are reduced.

In a standard internal combustion engine, an exhaust valve is usually opened before the associated piston reaches bottom dead centre (BDC) to allow the continuing expanding gases to rush out of the exhaust, thereby assisting the entrance of a fresh charge of fuel and air into the cylinder during valve overlap (that is to say when both the inlet and outlet valves are open), such that the exhaust gases are effectively scavenged from the combustion chamber. The act of

opening the exhaust valve early promotes the emission of unburnt hydrocarbons, and prevents the continuing expanding gases from providing mechanical rotation of the crankshaft, as these gases are vented to atmosphere. The use of the springs 39, however, not only allows more efficient use of the fuel/air mixture, but, if used with an increased compression ratio, allows the use of a cam shaft designed such that the exhaust valve remains closed until almost BDC. The clearance volume in the cylinder will, therefore, be considerably reduced, thereby effectively clearing most of the exhaust gases from the combustion chamber without the need to release the pressure in the cylinder by opening the exhaust valve early. This late opening of the exhaust valve cam design can be applied advantageously to any engine utilising the springs 39.

The use of the disc springs 39, coupled with the mass of the engine's flywheel, gives the whole assembly a frequency (rpm) at which it is resonant. This could be used to advantage when employed in an engine designed to run at a constant speed.

It will be apparent that modifications could be made to the piston/connecting rod assembly described above. In particular, any suitable form of spring could be used in place of the stack of titanium springs, and this spring could be positioned anywhere between the piston crown and the crank pin. For example, a spring could be mounted between the top (the small end) and the bottom (the big end) of the connecting rod 34. It would also be possible to make the disc springs of spring steel. The various parts of the assembly could also be made of any standard material, for example the piston could be made of titanium, cast iron or a high tensile silicon and aluminium alloy.

The piston/connecting rod assembly described above could be used in any form of reciprocating internal combustion engine, with any arrangement and number of cylinders, utilising any type of fuel such as petrol , diesel, gas or steam. It could also be used in a compressor where the loss of heat energy is usually significant.

CLAIMS

1. A piston and connecting rod assembly for an internal combustion engine, the assembly comprising a piston, a connecting rod, and a spring, the connecting rod having a first end operatively associated with the piston for movement therewith, and a second end connectible to a rotary output shaft, wherein the spring acts between the piston and the connecting rod to bias the connecting rod away from the crown of the piston.

2. An assembly as claimed in claim 1, wherein the piston is hollow, and the connecting rod is connected to the piston by a gudgeon pin.

3. An assembly as claimed in claim 2, wherein the spring acts between the piston crown and the gudgeon pin, the gudgeon pin being movable relative to the piston in the axial direction thereof.

4. An assembly as claimed in claim 3, wherein the gudgeon pin is mounted within a carrier which is slidably mounted within the hollow piston for axial movement relative thereto.

5. An assembly as claimed in claim 4, wherein movement of the carrier within the piston is limited by the spring in the direction of movement towards the crown, and by a stop member fixed in the interior of the piston in the direction of movement away from the crown.

6. An assembly as claimed in any one of claims 1 to 5, wherein a set of disc springs constitutes the spring.

7. An assembly as claimed in claim 6, wherein the disc springs are made of titanium.

8. An internal combustion engine comprising a cylinder, a piston and connecting rod assembly as claimed in any one of claims 1 to 7, a rotary output shaft, means for igniting a fuel/air mixture in the cylinder, and means for actuating the ignition means, the actuating means being such that ignition takes place before the piston reaches TDC on the compression stroke, and the arrangement is such that the spring is compressed, by the expanding gases resulting from the

combustion following ignition, before the piston reaches TDC.

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Claims searched: 1 to 8

Examiner: John Twin
Date of search: 11 December 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): F1B (B5R1H); F2T (T26)

Int Cl (Ed.6): F16J 1/12; F02B 75/32, 75/38

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2080484	(Snell)	1 at least
X	GB 705411	(Johnson) - see eg fig.11	1 at least
X	WO 85/01312 A1	(Polesy)	1-5 at least
X	US 2372472	(Campbell)	1 at least
X	US 2323742	(Webster)	1-5 at least
X	US 1539769	(Poillon)	1 at least
X	US 669416	(Johnson)	1 at least
X	DE 3414041 A1	(Gohle) - see eg WPI abstract accession no. 84-264832[43]	
X	DE 3139686 A1	(Derer) - see eg WPI abstract accession no. 83-F4982k[17]	

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